

DETERMINANTS OF DEBT IN MEXICAN HOUSEHOLDS: A NEUTRAL NETWORK ANALYSIS

Héctor Eduardo Díaz Rodríguez, ^a
Miriam Sosa Castro ^b and
Alejandra Cabello Rosales ^a

^a National Autonomous University of Mexico (UNAM), Mexico; ^b Autonomous Metropolitan University, Iztapalapa Campus, México.
Email addresses: diazrhe@economia.unam.mx; msosac87@hotmail.com and acr2001mx@yahoo.com.mx, respectively.

Date received: October 15th 2018. Date accepted: May 6th 2019.

Abstract

In recent years, consumer credit in Mexico has grown in significant ways. Credit cards, which represent 52% of credit in the country, grew by 19% from 2011 to 2018, while the average debt per card increased by 62%. This increase generates problems of over-indebtedness in Mexican households. Using microdata from the National Income and Expenditure Survey (NIES), this research seeks to identify the factors that affect over-indebtedness in households, and to offer an explanation of said phenomenon using a neural network methodology. The principal determinant of overindebtedness in Mexican households is the existence of bank credit, given that this indicates a long-term transfer of family income to the financial sector.

Keywords: financial debt; consumer credit; acquiring power; commercial banking; artificial neural networks.

1. INTRODUCTION

Consumer credit in Mexico has recently experienced significant growth as a result of, among other things, a credit expansion on behalf of department and retail stores, catering to a segment of the population which is most at risk and is not served by traditional commercial banks. Said credit expansion has been spurred by a growing need to use credit by a part of the population, which tends to be older, and by real wages experiencing recurring losses in purchasing power.

Consumer credit allows different strata of the population to access durable goods (such as cars or homes) by leveraging future income, thereby smoothing consumption patterns over their life cycle (Salgado and Chovar, 2010; Martínez-Carrascal and Río, 2004). This turns out to be even more relevant in the case of families in lower socio-economic levels where income, reserves, and the ability to save are in general low, making it difficult to acquire these goods. Credit therefore constitutes an important tool in acquiring durable goods. Nevertheless, the other side of having credit is monthly interest payments, which means that "an increase in debts represents a greater financial burden in the form of interest payments and paying back the debt and can, in certain circumstances, reduce the ability of the sector to react when faced by an unfavorable change in their income really." (Martínez-Carrascal and Río, 2004, p. 49).

Indebtedness represents an opportunity to increase consumption and investment; however, drawbacks arise when it is used disproportionately, thereby exposing the user to the risk of falling into arrears and putting the family's assets at risk, and in an aggregate form, compromises economic stability. In this regard, financial indebtedness imposes a greater burden for and reduces the economy's ability to respond when faced with variations in interest rates, thereby intensifying the effects of economic instability.

Due to the adverse effects generated by over-indebtedness, both at a macro-economic level as well as in individual homes, its study is ever more relevant. This work has as its objective to analyze which are the determinants of over-indebtedness in Mexican homes (those with expenses 40% greater than their income), as well as to offer some possible explanations with regards to the political economic factors which favor this configuration.

In the beginning, the analysis proposed is short-term in nature and uses data from the National Banking and Securities Commission (CNBV, 2018) in order to analyze that which is available in the market and the increase in credit and the probabilities of arrears. And, on the side of demand, we use the National Survey of Household Incomes and Expenditures (ENIGH¹), which allows one to analyze the use of credits, the level and the factors which determine over-indebtedness of households. The methodology chosen to analyze the topic is that of artificial neural networks (ANN), which allows the analysis of both lineal relationships as well as nonlinear ones.

This paper is organized in the following manner: the second section reviews studies related to the proposed topic. The third section presents, along with data from ENIGH (INEGI, 2016)², a statistical analysis of the state of indebtedness of Mexican households; while in the fourth section, the ANN methodology is explained. The results of the analysis are located in the fifth section and, lastly, we present the conclusions derived from the study in the sixth.

2. REVIEWING THE LITERATURE

The role of credit and indebtedness in an economy has been widely studied from a variety of viewpoints. For example, on the side of credit, its role in investments is analyzed and, along those lines, the financing system as an effective method of connecting surplus units with those seeking credit for investment³ (Samuelson and Nordhaus, 1992).

In terms of the use of credit, the thoroughly developed literature to analyze credit in relationship to investment is much more numerous than that which links credit to consumption. Schumpeter (1976) states that "it is not part of an individual's nature to obtain debt for consumption [...]. As such, we are not interested in the phenomenon of consumer credit". The economy, and in particular the financing system analyzed by Schumpeter, is quite removed from the current one.

From the point of view of indebtedness, the theory of Minsky (1992, 2008) has been *par excellence*, and the starting point for the analysis of different debt frameworks for businesses, with the theory of financial instability, which maintains that loans go through three different stages (Hedge, Speculative and Ponzi).

Minsky himself recognizes that his analysis of financing and indebtedness is created with primarily businesses in mind, though he does rule out the possibility that at some moment, similar models of propagating indebtedness could occur in households (Minsky, 2008).

Recently –as financing systems acquire greater relevance –, in the national sphere as well as on a global scale, there has been an important growth in studies analyzing the role of financial inclusion (in other words, the degree to which the population has access to the banking system) in order to explain economic growth; in this regard, the majority of related research considers an ample number of variables which, to different degrees, bestow upon financial inclusion a fundamental role in the economic development of nations or regions through three principal mechanisms:

1. the financing system improves the efficiency of distributing resources, thereby making it possible to increase investments (Rajan and Zingales, 1995; Claessens, 2005; Demirg and Levine, 2008; Clarke *et al.*, 2003; Honohan, 2004; Dehejia and Lleras, 2007; Levine, 2005).
2. smoothing out economic cycles and improving the macroeconomic landscape (Dabla-Norris and Srivisal, 2013; Kose *et al.*, 2003).
3. at a micro level, increasing access to credit under conditions more favorable than those of informal credit (Campero and Kisser, 2013; Karlan *et al.*, 2013; Straub, 2003), thereby creating the possibility of growing capital as much in the sense of personal goods as in human capital (health and education).

Contrary to that proposed by the World Bank (2013), in the Global Financial Development Report, a greater financial inclusion would seem to not necessarily be directly linked to a greater level of well-being for the population; rather, as we shall see later on, it would seem that it is other tools by which the greater penetration of the financing and credit system have affected or impacted Mexican households.

This can be seen in the growing proportion of credit in the country which is directed to consumption rather than financing business projects and which in turn has resulted in a small proportion of the banking system's available resources to be directed to the stockpiling and growing of capital reserves.

Various studies analyze how credit acts in family indebtedness. Along these lines, Salgado and Chovar (2010) analyze the impact of credit cards and mortgages on over-indebtedness of Chilean households. Using a probit and bivariate probit model, they find that having consumer credit tools (such as department store credit cards) are the primary factors which determine over-indebtedness.

Del Río (2002) analyzes the situation of personal assets in Spanish households; creating an error correction model to identify five factors associated with the behavior of debt and finds that "the reacquisition of value which Spanish families have experienced due to real estate wealth played an important role in the recent evolution of their debts." (Del Río, 2002, p. 2).

Martínez – Carrascal and Río (2004, p. 49) recognize that if there are benefits related to the presence of bank credit, an increase in bank debt implies a "greater financial burden in the form of interest payments and paying back the debt, and can reduce under certain circumstances, the sector's ability to respond when facing an unfavorable evolution of their income, their assets or the cost of financing".

By monitoring the growth of credit in Chilean households, Ruiz-Tagle *et al.* (2013) find that this phenomenon has occurred primarily in the poorest quintils of the population. They identify the direct effects of shock (health, income, and educational expenses) on indebtedness in households and find that these effects are heterogeneous and depend on the level of income.

Fatoki (2015) researches the causes and consequences of over-indebtedness in South Africa. The empirical evidence points to the existence of two groups of factors which determine the presence of high levels of indebtedness; on the one hand, factors on the side of supply, such as credits with a high cost due to the high level of risk, as well as the demand (the population's low income and inability to pay). On the other hand, internal and external factors of the countries, such as the scarce development of the financial system in their interior or the state of public debt are aspects which determine over-indebtedness in households.

Pradilla (2015) analyzes the conditions of over-indebtedness in Colombian households with the hopes of finding the characteristics which influence situations of over-indebtedness. The findings of the research revealed the importance of variables such as income, the balance of the debt, number of household members, and the age and marital status of the head of household in order to explain the behavior and conditions of indebtedness.

Romero (2018) studies the financial and socio-demographic factors which influence over-indebtedness in Ecuador. The results suggest that the primary determinants are: personal income, the age of the head of household, the number of members in the household and, once again, a link to the financing system be it through a mortgage or a credit card.

In regards to the works which analyze over-indebtedness in Mexico, there are those done by Morales *et al.* (2013), which studied the situation of commercial banking in the country; and observed the worsening of unpaid debt in different consumer segments, which is reflected in families' and households' over-indebtedness. Angulo (2014), analyzes the social implications of the most common micro-finance institution practices in order to reduce risk and confront over-indebtedness in their clients; the evidence suggests that the combination of economic and social components result in micro-financing programs, feeding back into debt models when the original choice of credit beneficiaries is not appropriate.

At the level of personal finance, there are works which study the determinants of credit card use (Vazquez, 2015; Solano *et al.*, 2015) and others which research the use given to these by different segments of the population (Contreras *et al.*, 2017). The cross-sectional variables in studies, where the excessive use of credit arises are circumstances where there are medical, educational, or rather family emergency expenses. This is an indicator of public services for health and education being insufficient in order to meet the needs of the population without risking their personal assets.

Nevertheless, there are no studies which delve into the factors which determine over-indebtedness of households. With this in mind, the present work employs a robust and leading-edge methodology in order to analyze the determinants of over-indebtedness in Mexico, using microdata provided by the ENIGH (INEGI, 2016). Prior to the mathematical development, there was a descriptive statistical analysis based on said survey, allowing the contextualization of the problem and contemplating the empirical analysis.

3. CHARACTERISTICS OF INCOME AND EXPENSES IN MEXICAN HOUSEHOLDS

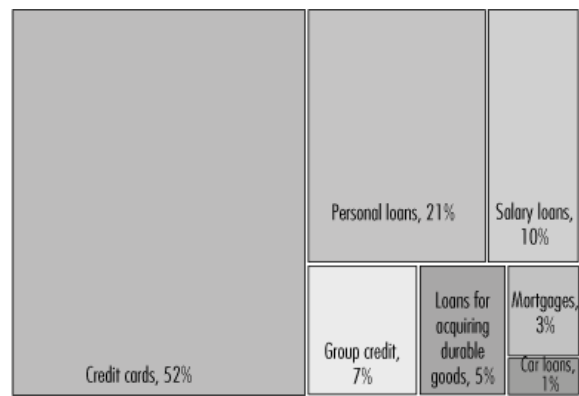
The growing use of credit in Mexico can also be analyzed from the point of view of the income received by households in relation to their expenses. In the latest version of the ENIGH (INEGI, 2016), one can see that 46.5% of Mexican households have total expenses (everyday expenses plus unexpected expenses) greater than their income. The conditions permitting a household to have expenses greater than their income in a specified period is the existence of prior savings or the possibly of accessing some form of credit.

In the case of Mexico, the makeup of commercial banking and the credit bestowed by department and retail stores determines a specific pattern of indebtedness in households which needs to be understood. With this goal in mind, the National Council for Financial Inclusion (2017) refers to credit cards⁴ as the product most

bestowed by commercial banking with 26 million registered contracts at the end of June 2016, followed by personal and salary loans, with 10.5 and 5.2 million respectively. In addition to these numbers we can add group credits at 3.4 million, the so-called acquisition of durable goods credits at 2.7 million, and mortgages at 1.5 with car loans taking last place at 0.6 million contracts. This data generally coincides with that reported by the ENIGH (INEGI, 2016) (see table 1).

This shows that 9.6% of credit aimed at households in Mexico aims to grow capital reserves (acquiring durable goods, mortgages and car loans); while the remaining 90.4% are destined for some form of financing for everyday household expenses. As such, contrary to what the literature states, credit in Mexico is not being used for acquiring assets or for investments which increase the abilities of household members, but rather to acquire consumables (food, clothes, shoes, medical emergencies, etc.).

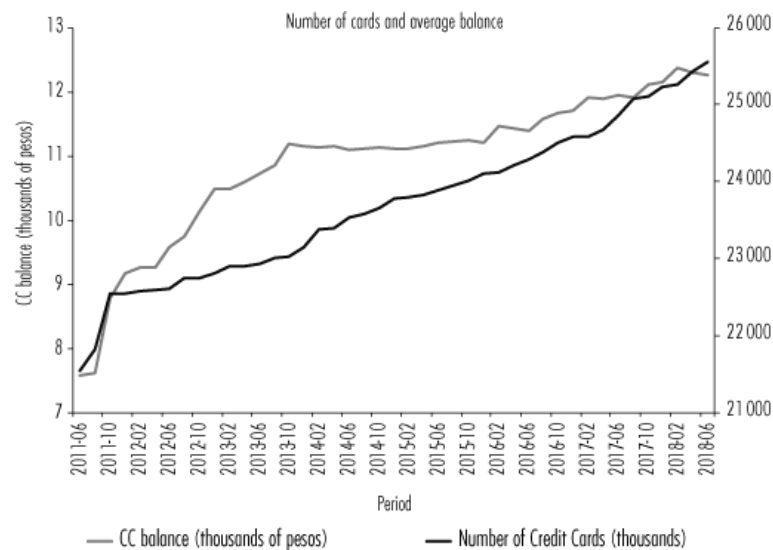
Figure 1. Credit and its distribution in Mexico, 2016



Source: created by the authors based on INEGI, 2016

Figure 2 shows that both the total number of credit cards and the average balance per card, as one can see, saw significant growth. The number of cards went from 21,547,000 in June 2011 to 25,549,000 in June 2018, with an annual growth of 2.5%. This, on the one hand, is an indicator of the growth of consumer credit used in the economy and on the other that in the case of the Mexican economy, the percentage of the population which uses a credit card as a method of accessing consumer credit tends to grow in a continuous manner. As such, the average amount of growth increased 62% in the same period by 9% annually.

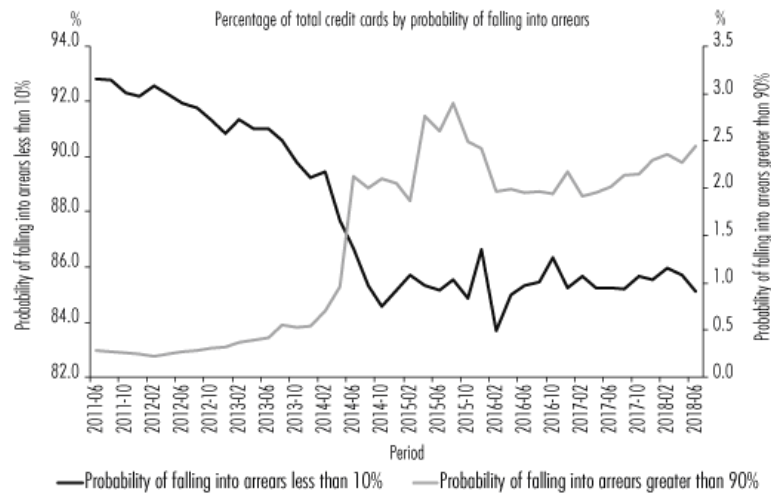
Figure 2. Growth of people with large debts, 2011-2018



Source: National Banking and Securities Commission

A growth in family indebtedness in addition to a lack of real growth in salaries has resulted in the quality of credit worsening significantly. The third figure shows the probability of falling into arrears with credit cards for two segments of the population. As one can see, the segment least likely to fall into arrears shrinks from 93% in June 2011 to 85% in June 2018. The counterpart is the segment with the highest probability of falling into arrears (greater than 90%), which grows at an accelerated rate, going from 0.3% to 2.4% in the same period. This is a worrying indicator if we think about the trend: a great number of credit card users with one segment, likeliest to fall into arrears, steadily growing while the segment least likely to fall into arrears is steadily shrinking.

Figure 3. Quality of indebtedness in credit cards, 2011 – 2018



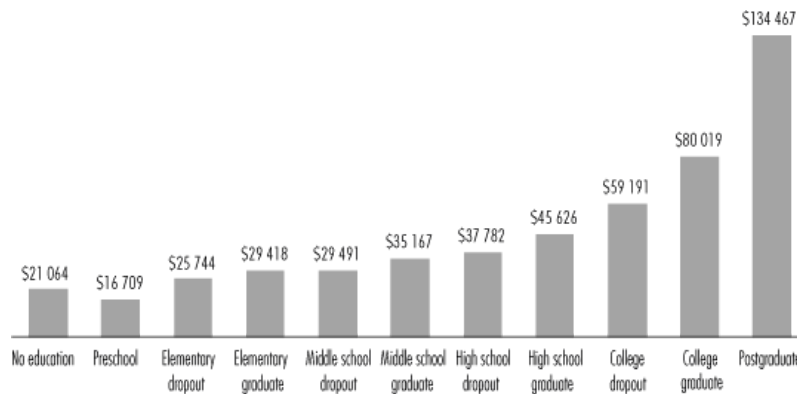
Source: National Banking and Securities Commission, 2018.

In order to understand this behavior it is necessary to look closely at the income and expenditure patterns of households. The ENIGH (INEGI, 2016) shows income, consumption and debt patterns, which one must analyze in order to understand the features of these households and the reasons for which they decide to become indebted or not. Next, we will analyze some of the features at the level of descriptive statistics; thereby obtaining preliminary information on income and expenditure patterns in these households as a step prior to mathematical analysis.

Figure 4 shows that there is a positive relationship between income and educational levels of the head of household. For low educational levels (no education, preschool, elementary school graduate or elementary school dropout) the average income per household does not exceed \$10,000 Mexican pesos per month; if we consider families to be composed of 3.8 people on average, the average income per person, in this educational segment is little more than \$2,500 Mexican pesos per month.

For the educational levels ranging from middle school dropout to high school graduate, monthly incomes in households vary between \$10,000 and \$15,000 Mexican pesos per month per household or around \$3,000 per month per person. For households who have a head of household with an education at the postgraduate level, monthly income rises significantly, reaching a bit over \$44,000 Mexican pesos per month, with an average income per household member of \$14,000 monthly.

Figure 4 Educational level and trimonthly income (in MXN pesos) per household, 2016



Source: created by the authors with data from INEGI, 2016.

Table 1 shows the salary difference per educational level but now taking into account the gender of the head of household; as one can see the salary differences between men and women is practically null for low educational levels (elementary school graduate), and in some cases, we even see female heads of households with greater income than men; nevertheless, as we progress to higher educational levels, the difference tends to favor men more than women. Finally, we get to the point of undergraduate and postgraduate studies where the difference shoots up to 21 and 57%, respectively.⁵

Table 1. Salary difference in households by gender of head of household

<i>Educational level</i>	<i>Men (\$)</i>	<i>Women (\$)</i>	<i>Salary difference (%)</i>
No education	21 264	20 758	2
Preschool	16 046	17 637	-9
Elementary dropout	26 081	24 912	5
Elementary graduate	29 192	30 062	-3
Middle school dropout	30 413	26 564	14
Middle school graduate	35 266	34 864	1
High school dropout	38 252	35 459	8
High school graduate	45 869	44 594	3
College dropout	59 134	59 390	0
College graduate	82 974	68 820	21
Postgraduate	147 251	93 822	57

Source: created by the authors with data from the INEGI, 2016.

This information can be analyzed taking into consideration a different level of aggregation, such as the socio-economic level; along those lines, the ENIGH uses four distinct levels, whose distribution of selected variables is shown in table 2. As one can see, if all the households in the study are taken into account, only 7% of households fall into the highest socio-economic level. Likewise, as one rises in socio-economic levels, the ability to save as a percentage of income tends to be greater; in fact, for all the levels there is a positive capacity for savings, which goes from 4.6% of income until 8.8% in the case of the highest level.

Table 2. Households savings (income - expenses) per socio-economic level in Mexico

<i>Socio-economic level</i>	<i>Distribution of households</i>	<i>Average trimonthly income per household (\$ MXN)</i>	<i>Average trimonthly savings per household (\$ MXN)</i>	<i>Savings as percentage of income (%)</i>
High	1 492	92 592	8 183	8.8
Medium-high	3 776	50 143	3 351	6.7
Medium-low	10 200	34 183	1 879	5.5
Low	4 011	21 762	1 012	4.6
Overall total	19 479	39 193	2 469	6.30

Source: created by the authors with data from INEGI, 2016.

The grouping of information in table 2 does not allow one to directly see the state of indebtedness of households. Table 3 only contemplates a little bit over 9000 households (46% of the total sample), which have trimonthly expenses greater than their income, in other words, only households which are considered to be in some type of debt⁶. What we can see is that on average low socio-economic level of this sub- grouping of households spends on average 34% more than its received income; the debt of households in the highest socio-economic level tends to be 3 to 4% less, coming out at 31% for the medium-low socio-economic level, 30% for the medium-high level and 31.3% for the highest level (see table 3).

Table 3. Households with negative savings by socio-economic level

<i>Socio-economic level</i>	<i>Distribution of households</i>	<i>Average trimonthly income per household (\$MXN)</i>	<i>Average trimonthly savings per household (\$MXN)</i>	<i>Debt as percentage of income (%)</i>
High	641	70 615	-22 114	-31.3
Medium-high	1 619	40 897	-12 308	-30.1
Medium-low	4 827	26 994	-8 333	-30.9
Low	1 972	16 563	-5 696	-34.4
Overall total	9 059	30 295	-9 445	-31.2

Source: created by the author with data from the INEGI, 2016.

This situation could be explained, given the low level of everyday income received by households in the lowest, socio-economic level (around \$5,500 Mexican pesos per month per household), their financial vulnerability when faced with eventualities such as sickness or other types of unforeseen expenses tends to be much greater, leaving debt as a viable way out.

This shows that the proportion of indebtedness in households with lower socio-economic level tends to be greater, a fact which increases the probability of becoming over-indebted due to the difficulty that these segments face in generating income greater than their expenses in quantities that will allow them to cover the acquired debt and the payment of corresponding interests (Speculative stage in the Minsky model of business debt).

The goal of this work is to find the factors which determine the existence of over-indebtedness at the level of households. As the total percentage of households which find themselves in the situation tends to be greater, the risks associated with growing debt takes on dimensions which scale towards the level of macroeconomics.

To this we must add that if certain types of over-indebtedness can be related to very specific behaviors and variables of households, in general when close to 50% of households show recurring expense patterns greater than their income, the causes of indebtedness must be sought out at the macroeconomics level and in the economic policies which have contributed to the configuration.

4. METHODOLOGY

In order to evaluate which variables determine the level of indebtedness in Mexican households, we used an ANN methodology. We chose this methodology as it allows one to evaluate linear causal relationships as well as nonlinear ones; which to begin with allows one to advance the understanding of the behavior of complex systems, as is the case of the units of study herein analyzed. Furthermore, ANN analyses allow one to obtain, under certain circumstances, superior results than those of econometric models (Arrieta *et al.*, 2009; Piñeiro *et al.*, 2013).

This form of evaluation consists in a simulation of the human brain's learning process. Each one of the observations is used to generate knowledge in the way that (functional form, which can be linear or nonlinear) transmission of included variables included in the model occurs towards the learning variable (dependent variable).

Contrary to what happens in econometric models, where one assumes a functional form *a priori*, linked to the type of model to be considered for estimation, via ANN the functional form is determined via its own learning process and does not depend on fulfilling cases of "good behavior" linked to the type of selective model.

According to Longoni *et al.* (2010), ANNs are tools whose potential consists in analyzing data with the goal of discovering and modelling the functional relationships between variables. Furthermore, they allow one to explore relationships or models which might not have been discovered using traditional statistical procedures.

This happens due to the learning process; if by this process one determines that the impact on the output layer has a nonlinear form, then the functional form is adjusted in order to display nonlinear results; if a linear relationship is what best describes the relationship between the input layer and output layer, the hidden layer will estimate in a linear fashion and will ignore those relationships which are redundant or which do not exercise an impact on the output layer.

As such, the ANN model is made up of three parts: the first is known as the input layer, made up of the variables which theoretically impact the determination of the variable to be estimated. The second part is known as a hidden layer; it is here that the neural learning process occurs. Meanwhile the third is known as the output layer and is made up of the observations of the variable to be estimated.

The specific manner in which these three parts are structured is called the network architecture; while there are different architectures and types of networks, we chose to work with one specific type for its characteristics of reacting quickly to changes and alterations, which are known and measurable. In other words, a perceptron multilayer type network, whose method of learning is backpropagation.

As happens with real biological neurons, the information in ANNs is processed when the stimulus reaches a certain magnitude, otherwise it is ignored; this is achieved via a threshold value m_j , which is activated when the sum in question exceeds a determined value and it is only then that processed information output is considered valid. Contrary to what happens in econometric procedures, redundant information is excluded by the process itself. This is expressed in the following function:

$$\sum_j w_{ij} x_j - m_i \quad (1)$$

The activation thresholds are related to the intensity of synaptic connections, which in terms of ANN methodology are determined by an activation function, be it in hidden layers or in the output layer.

The hidden layers are characterized by not having a direct connection with their surroundings, rather they receive information and data from the input layer; it is here whereby the learning process that the characteristics obtained from the surroundings are modelled, presented and estimated by the function:

$$\text{Hidden layer: } a_j^1 = \sum_i w_{ji}^1 X_i + \theta_j^1; h_j = f^1(a_j^1) \quad (2)$$

Lastly, we have the output layer, made up by groups of neurons which provide the network's response by the function:

$$\text{Output layer: } a_j^2 = \sum_i w_{ji}^2 X_i + \theta_j^2; h_j = h^2(a_j^2) \quad (3)$$

The process of training neurons or the learning process allows one to get functional forms from the data acquired from the input layer and is carried out for a subgrouping of data $D = \{X^{(n)}, t^{(n)}\}$.

In a gradual manner, the input function W is adjusted by minimizing the error of the function by the method known as declining gradient, presented by the following function:

$$\begin{aligned} J(W_0) &\geq J(W) \\ J(W_{n+1}) &\geq J(W_n) \\ W_{n+1} &= W_n - \mu \frac{1}{2} \nabla J_w | W_n = W_n - \frac{\mu}{2} \frac{\partial J_w}{\partial w} | W_n \end{aligned} \quad (4)$$

$$E_D(w) = \frac{1}{2} \sum n \sum i ((t_i^{(n)} - y_i(x^{(n)}; w))^2 \quad (5)$$

The minimization is based on continuously evaluating the gradient ED via the chain rule in order to find derivatives.

The result of the minimization process via gradient descent is an approximation of output layer values and of a sample reserved from the total data, different from the observations used in the process of neural training.

Recently, efforts have been made to contribute to the interpretation of results estimated from neural networks and at least generate some information relating to the hierarchic order in which variables act on the subject of study. It is with this goal that we use a type of analysis based on the magnitude of the weights and, specifically, a group of tests based on the comparison of the synaptic weight matrix of the input layer towards the hidden layer, with the goal of obtaining information in relation to the impact or influence which input variables have on the output of the network. As such, in order to measure the synaptic weight of variables and their impact on the output variable, we have the following function (Montaño *et al.*, 2002):

$$Q_{jk} = \frac{\sum_{j=1}^L \left(\frac{W_{ij} V_{jk}}{\sum_{r=1}^N W_{rj}} \right)}{\sum_{i=1}^N \left(\sum_{j=1}^L \left(\frac{W_{ij} V_{jk}}{\sum_{r=1}^N W_{rj}} \right) \right)} \quad (6)$$

Thereby we estimated the analysis of the importance of the variable, which allows one to know the hierarchy (only in terms of order, but not of in terms of the magnitude of its impact) of the variables of the input layer on the output.

5. RESULTS

With the goal of corroborating the hypothesis, we applied the methodology described in the previous section to microdata provided by the ENIGH. Of the little more than 19,000 observations available in the survey, the ones considered for estimation in the ANN model were 9,059 households, which correspond to the units of study with expenditures greater than their income. As we can see in table 4, 71.4% of the data was used in the training stage (in other words to analyze the correspondence between variables of the input and output), 19.3% were used to carry out trials and the remaining 10.3% correspond to the reserve sample, used to validate the results.

Table 4. Summary of the processing of cases.

		<i>N</i>	<i>Percentage</i>
Example	Training	6 298	71.4
	Trials	1 707	19.3
	Reserve	819	9.3
Valid		8 824	100.0
Excluded		235	
Total		9 059	

Source: created by the authors with results from the ANN estimation.

In the model, we use as a dependent variable, the level of indebtedness, while the factors used were: the age of head of household, gender, educational level, socio-economic level, number of economic dependents, payment of credit cards and payment of other debts.

According to the theory, the age variable is negatively related to decisions regarding indebtedness. With greater age, individuals tend to accumulate greater knowledge and skills related to experience, and at the same time behave in a more stable and risk-free manner, which contributes to increasing the level of responsibility, thereby influencing their aversion to over-indebtedness.

On the other hand, as the productive age of people diminishes with time, they tend to save a greater percentage of their income in order to cover the needs or necessities of advanced age; meanwhile, as income increases and as people cover their basic necessities, they find themselves able to generate savings. Something similar happens when the educational level of families increases, a factor which provides the possibility of accessing jobs with greater salaries. As such, one would expect age as well as educational level to negatively impact the decisions of indebtedness.

With regards to socio-economic levels, theory dictates two ways things can go: on the one hand, socio-economic level is linked to the opportunity of having a greater educational level, so that in theory, high socio-economic levels have access to financial education and as such there is a lesser possibility that they will fall into debt. On the other hand, it is probable that a person with a high socio-economic level will have access to credit with a certain level of ease, as they have a greater income and securities.

Nevertheless, we also recognize that the socio-economic level is linked to a higher level of education and with a greater knowledge of legal and operational workings of the financial system; as such knowledge of a lack of sanctions when there is a breach of payment makes it so that on occasion, families from higher socio-economic levels will decide not to pay their debts when they face problems and challenges in fulfilling these obligations. On the other hand, people from low social economic levels do not have access to financing and do not know how it functions so that, in order to keep the door open to future credit and to avoid problems, they tend to have better patterns of fulfilling their credit obligations.

With regards to the variable of economic dependents, one hopes that with a greater number of economic dependents, there would be more needs to cover and make it more probable to fall into debt when faced with an eventuality. Along these lines, the variables of paying off credit cards and debts have a positive impact on the level of indebtedness and represent a financial burden which puts families in a precarious situation when faced with instability or negative eventualities (illness, accidents, death, among others). This is evidently clear in the case of the Mexican economy where the difference between active and passive interest rates is pronounced.

The network used is a multilayer perceptron type with one hidden layer; the input layer consists of 857 units (not including the bias unit). The number of units in the hidden layer is five, with a hyperbolic tangent activation function.

The output layer has one unit and was estimated with an identity activation function and an error function based on the sum of squares. The results are summarized in table 5.

Table 5. Network information

Input layer	Factors	1	Sex
		2	Socio-economic level
		3	Educational level
		4	Age, head of household
		5	Economic dependents
		6	Card payments
		7	Debt payments
	Number of units ^a	857	
Hidden layers	Number of hidden layers	1	
	Number of units in hidden layer 1 ^a	5	
	Activation function	Hyperbolic tangent	
Output layer	Dependent variables	1	Indebtedness
	Number of units	1	
	Scale change method for scale dependents	Standardized	
	Activation function	Identity	
	Error function	Sum of squares	

Note: ^a bias unit is excluded.

Source: created by the authors based on the results of ANN estimation.

Table 6 shows a relatively low estimation error for the model, insomuch for the trials carried out as well as the reserve sample which is used to validate the estimations. This indicates that the estimation is sound in terms of the selected variables.⁸

Table 6. Summary of model

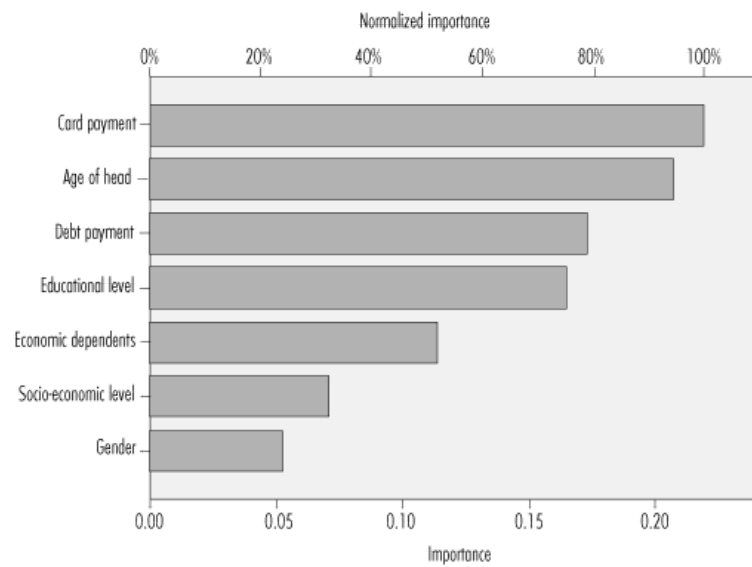
Training	Error of sum of squares	2967.052
	Relative error	.942
	Stopping rule used	1 consecutive step(s) without diminishing error ^a
	Training time	0:00:04.99
Trials	Error of sum of squares	389.062
	Relative error	.937
Reserve	Relative error	.928

Notes: dependent variable: indebtedness; ^a The error calculations are based on the sample for corroboration.

Source: created by the authors with the results from the ANN estimation.

The analysis of the importance of independent variables indicates how much the prognosticated value changes for the network model for different values of the dependent variables. The normalized importance is the result of the values of greater importance expressed as percentages (see table 5).

Figure 5. Normalized importance analysis



Source: created by the authors with results from the ANN estimation.

The evidence from this investigation indicates that for the model estimated, the most important variable determining the level of indebtedness is having a credit card.

If one considers that the variables for over-indebtedness and having credit cards are found to be interrelated, the neural network model allows one to understand that not all cases of having a credit card are related with over-indebtedness, but that specific patterns in the use of credit are what determine when it happens and when it does not.

This result is, perhaps, one of the most important ones of the study as it indicates that when people use a credit card, there is a great financial burden on the cardholder due to the high interest rates which commercial banks and department stores charge. This represents a drain on resources and lastly, a transfer of family income to the banking sector.

This result, while contrary to the majority of related studies, is intuitive, especially if one considers the total annual cost (the sum of interest rates along with banking commissions which one pays for a credit card), and represents a drain on a household's income, varying, depending on the type of card (between 56% and 177% per year on top of the amount of credit), according to data from the Bank of Mexico (2017)⁹. The fact that the cost of consumer credit and the difference between active and passive interest rates in Mexico is so great, helps to explain why the presence of valid credit is a factor which contributes to understanding families' over-indebtedness.

6. CONCLUSIONS

The objective of the study is to analyze the primary determinants of indebtedness in Mexican households. The analysis employs ANN methodology based on a model which proposes as the dependent variable over-indebtedness in households and, as independent variables, the age of the head of household, gender of the subject, educational level, socio-economic level, the number of economic dependents, amount paid to credit cards and the payment of other debts.

The importance of indebtedness can be analyzed from two distinct perspectives. In microeconomic terms it represents an opportunity for households to access resources which could boost their well-being, when the credit is employed in acquiring assets, or allows them to increase the abilities of those in the household; nevertheless, it is also a financial burden which imposes on households the obligation to pay interests, decreasing the level of their income in the long term and their ability to react when faced with eventualities (sickness, accidents, that of the head of the household, among others), exposing households to a loss of their personal assets. From an aggregate perspective, the financial burden which that indebtedness imposes on an economy limits its ability and the actions that they can take when faced with external instabilities, reducing their options in favor of re-activating their debt when faced with the crisis.

In terms of the Mexican economy, in the last 20 years private consumption has grown more than the product, in spite of a drop in the share of salaries in the product and the decreasing purchasing power of these. This has generated a growing tendency of over-indebtedness in a greater proportion of households. While in the current international context in which a type of financial regulation favoring international banking governs, specifically, in the Mexican context where foreign banks dominate, banking has served as a conduit for transferring the populations resources in general to capitals whose origins are found outside of the country.

In this regard, it is worth considering that based on the results of this research, which indicate the primary determinants in indebtedness in a population, the primary determinant of indebtedness in the population is having a credit card, which is used to cover part of everyday household expenses (buying shoes, clothes, food, medicine, etc.). Thereby indebtedness is not a result of a desire to improve the well-being of the population in the long term as theory would indicate, but rather to supplement the drop in real wages, introducing an element of risk and financial vulnerability as a result of, among other things, the establishment of inflation targeting which uses variable nominal wages as an anchor.

There are important implications to the findings of this research in terms of public policy and banking regulations. With regards to public policy, it is necessary to stop and compensate the drop in actual salaries, thereby diminishing inequality; banking regulations is one way that is one form of complementary policy to tend to the problem and could, under current circumstances, reduce high interest rates in consumer credit.

In the best of cases, from the perspective of orthodox theory, banking institutions need to create a credit profile for every client, based on a detailed investigation, thereby reducing the problem of asymmetrical information, which is the primary justification for the high interest rates associated with consumer credit. From the perspective of heterodox economic theory it is necessary to establish regulations in the financing sector which allow reducing the enormous transfer of family resources to the international financial sector via banks established inside the country.

One regulation which allows reducing the interest rates which commercial banks charge is a necessary condition, but in and of itself insufficient in order to reduce household over-indebtedness. This measure should be complemented with another policy which allows increasing the population's real wages; so that as income is enough the tendency to fall into over-indebtedness is lesser.

Contrary to the idea that a greater financial inclusion improves the well-being of families and reduces the risk of financial instability in economies due to access to formal credits being favorable compared to that of informal credit, there is no decisive information which assures that the bestowing of credit in formal markets with the interest rates reported in this study results in conditions more favorable than those of informal ones. On the contrary, it would seem that the current rules for the workings of the Mexican financial system allow for the presence of an enormous difference between active and passive interest rates. Smaller bank loans constitute a trigger factor in the over-indebtedness of households.

Along these lines, future lines of research could explore the impact of financial inclusion in terms of economic growth and the conditions of credit in formal and informal markets.

BIBLIOGRAPHY

- Angulo, L. (2014), "Prácticas financieras riesgosas para afrontar la crisis económica en los hogares: entre malabarismos con el dinero y sobreendeudamiento", *Desacatos*, no. 44, Mexico, January-April.
- Arrieta, J. E., Torres, J. C. and Velásquez, H. (2009), "Predicciones de modelos econométricos y redes neuronales: el caso de la acción de SURAMINV", *Semestre Económico*, vol. 12, no. 25, Colombia, Universidad de Medellín, July-December.
- Banco de México (2017), "Información Comparativa de Costos de Tarjetas de Crédito". Recovered from <<http://www.banxico.org.mx/tarjetascats>>
- Banco Mundial (2013), "Reporte de desarrollo Financiero Global: Repensando el papel del estado en las finanzas", Washington, DC, World Bank. Recovered from <<https://openknowledge.worldbank.org/handle/10986/11848>>
- Campero, A. and Kaiser, K. (2013), "Access to credit: awareness and use of formal and informal credit institutions", *Working Paper*, Bank of Mexico.
- Claessens, S. (2005), "Access to financial services: a review of the issues and public policy objectives", *World Bank Policy Research, Working Paper* S3589, Washington, D.C., World Bank.
- Clarke, G., Xu, L. and Zou, H. (2003), "Finance and income inequality: test of alternative theories", *World Bank Policy Research, Working Paper* 2984, Washington, D.C, World Bank.
- Comisión Nacional Bancaria y de Valores (CNBV) (2018), "Portafolio de Información de Tarjetas de Crédito", CNBV. Available at <<http://portafoliodeinformacion.cnbv.gob.mx/bm1/Paginas/tarjetascredito.aspx>>
- Consejo Nacional de Inclusión Financiera (2017), "8vo Reporte Nacional de Inclusión Financiera, Comisión Nacional Bancaria y de Valores", CNBV, Mexico. Recovered from <<http://www.cnbv.gob.mx/Inclusi%C3%B3n/ Documents/Reportes%20de%20IF/Reporte%20de%20Inclusion%20 Financiera%208.pdf>>
- Contreras, A., García, A., Juárez, I. K. and García, E. (2017), "Un estudio empírico sobre el hábito de consumo mediante el uso de tarjeta de crédito en jóvenes universitarios", *European Journal of Education Studies*, vol. 3, no. 9, DOI <<http://doi.org/10.5281/zenodo.852518>>
- Dabla-Norris, E. and Srivisal, N. (2013), "Revisiting the link between finance and macroeconomic volatility", *Working Paper*, no. 13/29, Washington D.C., International Monetary Fund.
- Dehejia, R. and Lleras, A. (2007), "Financial development and pathways of growth: state branching and deposit insurance laws in the United States, from 1900 to 1940", *Journal of Law and Economics*, vol. 50, University of Chicago Press.
- Del Río, A. (2002), "El endeudamiento de los hogares españoles", *Boletín Económico*, no. 0228, Spain, Bank of Spain.
- Demirg, Á. and Levine, R. (2008), "Finance and economic opportunity", *World Bank Policy Research, Working Paper* 4468, Washington, D.C.
- Fatoki, O. (2015), "The causes and consequences of household over-indebtedness in South Africa", *Journal of Social Sciences*, vol. 43, no. 2, DOI <<https://doi.org/10.1080/09718923.2015.11893427>>.
- Honohan, P. (2004), "Financial sector policy and the poor: selected findings and issues", *World Bank Policy Research, Working Paper* 43, Washington, D.C., World Bank.
- INEGI (2016), Encuesta Nacional de Ingresos y Gastos de los Hogares (ENIGH), Mexico, INEGI.
- Karlan, D., Ratan, A. and Zinman, J. (2013), "Savings by and for the poor: a research review and agenda", *World Bank Policy Research, Working Paper* 346, Washington, D.C., Center for Global Development.
- Kose, M.A., Prasad, E.S. and Terrones, M.E. (2003), "Financial integration and macroeconomic volatility", *Staff Papers*, vol. 50, International Monetary Fund.
- Levine, R. (2005), "Finance and growth: theory and evidence. Handbook of economic growth", in Ph. Aghion and S. Durlauf (eds.), *Handbook of Economic Growth*, edition 1, vol. 1, chapter 12, Elsevier.

- Longoni, M. G., Porcel, E., López, M. V. and Dapozo, G. N. (2010), "Modelos de redes neuronales perceptrón multicapa y de base radial para la predicción del rendimiento académico de alumnos universitarios", *XVI Congreso Argentino de Ciencias de la Computación*, Argentina.
- Martínez-Carrascal, C. and Río, A. D. (2004), "Las implicaciones del endeudamiento de los hogares sobre el consumo privado", *Boletín Económico*, Bank of Spain (12).
- Minsky, H. (1992), "The financial instability hypothesis. The Jerome Levy Economics Institute", *Working Paper*, no. 74. Available at SSRN: <<http://dx.doi.org/10.2139/ssrn.161024>>
- _____. (2008), *Stabilizing an unstable economy*, vol. 1, New York, McGraw-Hill.
- Montaño, J. (2002), *Redes neuronales artificiales aplicadas al análisis de datos*, (Doctoral Thesis), Spain, Universitat de les Illes Balears.
- Morales, F. J., Muñoz, G. and Uribe, E. A. (2013), "Sistema financiero y actividad económica en México: negocio y divergencia del sector bancario", *Análisis Económico*, vol. 28, no. 67, Mexico, UAM-Azcapotzalco.
- Piñero, C., De Llano, P. and Rodríguez, M. (2013), "¿Proporciona la auditoría evidencias para detectar y evaluar tensiones financieras latentes? Un diagnóstico comparativo mediante técnicas econométricas e inteligencia artificial", *Revista Europea de Dirección y Economía de la Empresa*, vol. 22, no. 3, DOI <<https://doi.org/10.1016/j.redee.2012.10.001>>
- Pradilla, D. (2015), *Determinantes de las condiciones de endeudamiento de los hogares colombianos* (Doctoral Thesis), Chile, Universidad de los Andes.
- Rajan, R. G. and Zingales, L. (1995), "What do we know about capital structure? Some evidence from international data", *The Journal of Finance*, vol. 50, no. 5, DOI <<https://doi.org/10.2307/2329322>>^[1]_{SEP}
- Romero, J. X. (2018), *Los factores financieros y sociodemográficos que influyen en el sobre-endeudamiento de los hogares ecuatorianos para el año 2014* (Masters Thesis), Ecuador, Universidad de Cuenca.^[1]_{SEP}
- Ruiz-Tagle, J., García, L. and Miranda, A. (2013), "Proceso de endeudamiento y sobre endeudamiento de los hogares en Chile", *Documento de trabajo*, 703, Banco Central de Chile.^[1]_{SEP}
- Salgado, H. and Chovar, A. (2010), "¿Cuánto influyen las tarjetas de crédito y la deuda hipotecaria en el sobre endeudamiento de los hogares en Chile?" *Departamento de Economía*, no. 12-2010, Chile, Universidad de Concepción.
- Samuelson, P. A. and Nordhaus, W. D. (1992), *Economics*, New York, McGraw-Hill.
- Schumpeter, J. (1976), *Teoría del desenvolvimiento económico: una investigación sobre ganancias, capital, crédito, interés y ciclo económico*, Mexico, Fondo de Cultura Económica.
- Solano, M. C., Vega, L. V. and Cárdenas, L. F. (2015), "Determinantes del uso de tarjetas de crédito en México. Reflexiones sobre el papel de la cultura financiera", *Revista RAITES*, Year 1, no. 1, Mexico, Red de Investigación en Administración de la Innovación Tecnológica, Económica y Sustentable.
- Straub, S. (2003), "Informal Sector: 'The credit market channel'", *Working Paper*, Scotland, University of Edinburgh.
- Vázquez, A. (2015), "Determinantes para participar en el mercado formal de productos financieros: el caso del ahorro y del crédito en México", *Estudios Económicos CNBV*, vol. 3, Mexico, CNBV.

¹ From the name in Spanish Encuesta Nacional de Ingresos y Gastos de los Hogares.

² It is worth mentioning that what is considered as indebtedness is that registered as such by the ENIGH, in other words it primarily means indebtedness in formal markets such as commercial banks, micro financing establishments and others.

³ Typical textbook point of view, it would appear to have fallen in disuse, and due to proposals of endogeneity and the non-neutrality of money made by the post-Keynesian school of thought.

⁴ Citibanamex is the institution which reported the highest number of credit cards with 7.4 million, followed by BBVA Bancomer with 6.1 million, Bancoppel with 3.4 million and Santander at 2.8 million.

⁵ while this is not the research subject of this work, these numbers show great gender discrimination when it comes to getting qualified job positions with a high income.

⁶ There is the possibility that this expense surpassing income comes from some type of pre-existing savings; nevertheless, we verified that households did not have deposits in savings accounts, group savings, savings bank, etc. In the case of a household that had this variable, it was excluded from the sample.

⁷ In general, econometric levels assume cases of normality, homoscedasticity, non-multicollinearity, even co-integration requirements, etc. relative to the specific functional form which each model possesses.

⁸ For the neural training, in the form of a scaled conjugate gradient, we started with an initial lambda value of 0.0000005, and initial Sigma value of 0.00005 and a shift in the interval of ± 0.5 .

⁹ In the case of the most used credit cards (classic cards), with data consulted on December 23, 2017 from the Bank of Mexico (2017), the cost of credit (total annual cost) varies between 56.7% and 177.7%. In the case of credit offered directly by department stores, the value is between 44.9% and 90.2% (CONDUSEF).